

FIG.1

COMPARISON BETWEEN CHARACTERISTICS OF KINETIC FUNCTION MATERIALS

	IONIC POLYMER- GEL metal composites ⁽¹⁾ PRODUCED BY FREEZING- DEFROSTING METHOD ⁽²⁾	SHAPE MEMORY ALLOY ⁽³⁾	PIEZOELECTRIC CERAMIC ELEMENT ⁽⁴⁾	RUBBER ARTIFICIAL MUSCLE ⁽⁵⁾	INTERCALATION MATERIAL ⁽²⁾	BIOMUSCLE ⁽³⁾
DISPLACEMENT	20 - 30%	8%	0.1%	20%	[Amino-TiNbO ₅] SEVERAL TIMES (REACTION DRIVE TYPE) 30% ELECTRIC FIELD DRIVE TYPE)	50%
FORCE (MPa)	10 - 30	588	300			0.5-1
SPEED OF RESPONSE	>0.2 sec	sec to min	μ sec			0.03-0.2sec
DRIVE METHOD	APPLICATION OF VOLTAGE (4-7 V) CHANGE IN SOLUTION	CHANGE IN TEMPERATURE	APPLICATION OF VOLTAGE (50- 800V)	CHANGE IN PNEUMATIC PRESSURE	CHANGE IN SOLUTION (APPLICATION OF VOLTAGE)	
OUTPUT-WEIGHT RATIO	-	0.1W/g				0.1-0.3W/g
LABORATORY	NEW MEXICO UNIVERSITY MECHANICAL TECHNOLOGY RESEARCH	NAGAOKA TECHNOLOGY/SCIENCE UNIVERSITY		BRIDGESTONE CORPORATION		

1 "Ionic Polymer-Metal Composites (IPMC) As Biomimetic Sensors, Actuators and Artificial Muscles-A Review"
M. Shahinpoor et al. (University of New-Mexico) <http://www.unm.edu/~amri/paper.html>

2 "ORGANIC INTERCALATION ON LAYERED COMPOUND KTiNbO₅" S.KIKKAWA and M.KOIZUMI (Osaka Univ.)

Physica 105B (1981) 234

3 "ARTIFICIAL MUSCLE", MAKOTO SUZUKI (MECHANICAL TECHNOLOGY RESEARCH), APPLIED PHYSICS, 60(1991)256

4 "ACTUATOR PRACTICAL DICTIONARY", SUPERVISED BY SHOUTAROU MIYAIRI, FUJI TECHNO SYSTEM (1988)

5 "ARTIFICIAL MUSCLE" EDITED BY HITOSHI MIYAKE, KAMEDA BOOK SERVICE (1998)

FIG. 2

DIFFERENCE BETWEEN ELECTROMAGNETIC WAVE
AND SOUND WAVE IN TERMS OF WAVELENGTH

	NAME OF SOUND WAVE (ULTRASONIC WAVE)	WAVE- LENGTH, λ	NAME OF ELECTRO- MAGNETIC WAVE	
1GHz	VERY HIGH FREQUENCY ULTRASONIC WAVE	380nm	VISIBLE LIGHT RAY	
		780nm	NEAR INFRARED RADIATION	
		1.5 μ m	MID INFRARED RADIATION	
		5 μ m	FAR INFRARED RADIATION	
1MHz	HIGH FREQUENCY ULTRASONIC WAVE	100 μ m	VERY FAR INFRARED RADIATION	3THz
	LOW FREQUENCY ULTRASONIC WAVE	1mm	MILLIMETER WAVE	300GHz
20KHz		1cm	MICROWAVE	30GHz
	AUDIBLE SOUND WAVE (HIGH TEMPERATURE)	10cm	SUPERHIGH HIGH FREQUENCY WAVE	3GHz
		1m	VERY HIGH FREQUENCY WAVE	300MHz
20Hz	AUDIBLE SOUND WAVE (LOW TEMPERATURE)	10m	HIGH FREQUENCY WAVE	30MHz
	LOW FREQUENCY WAVE			

FIG. 3

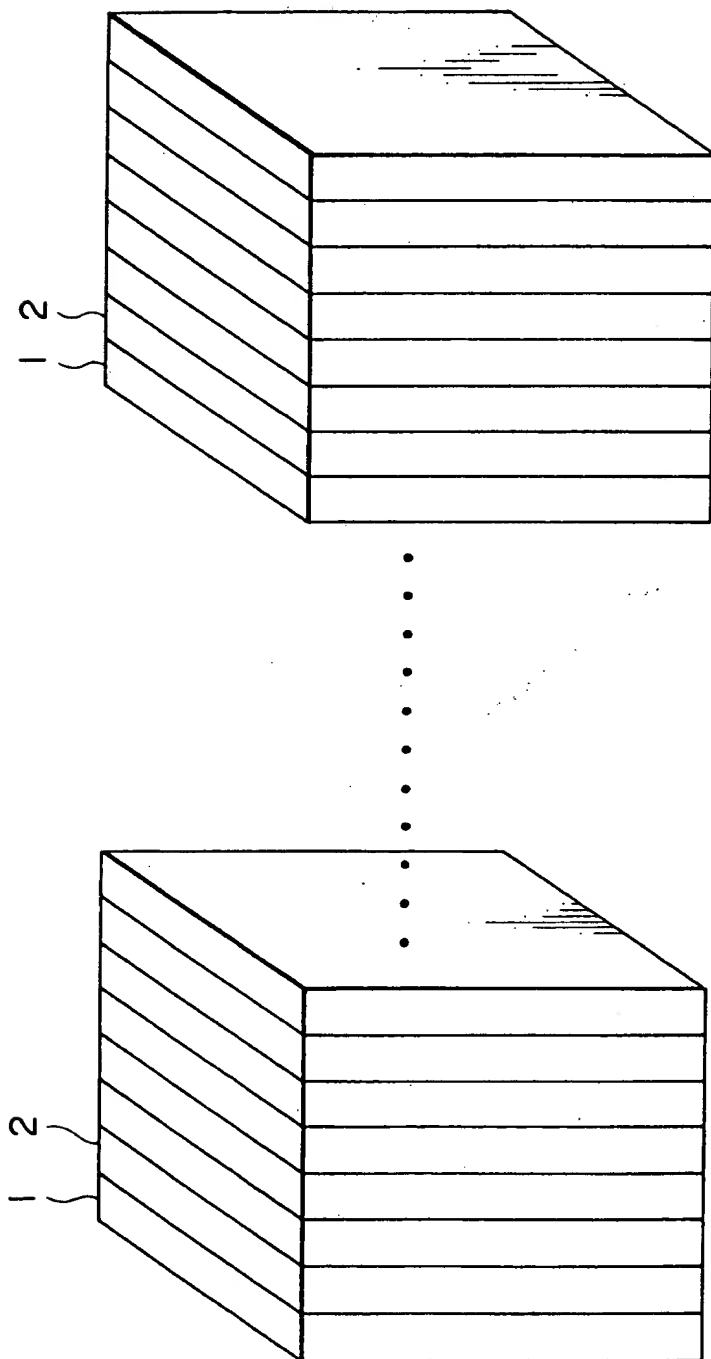


FIG. 4

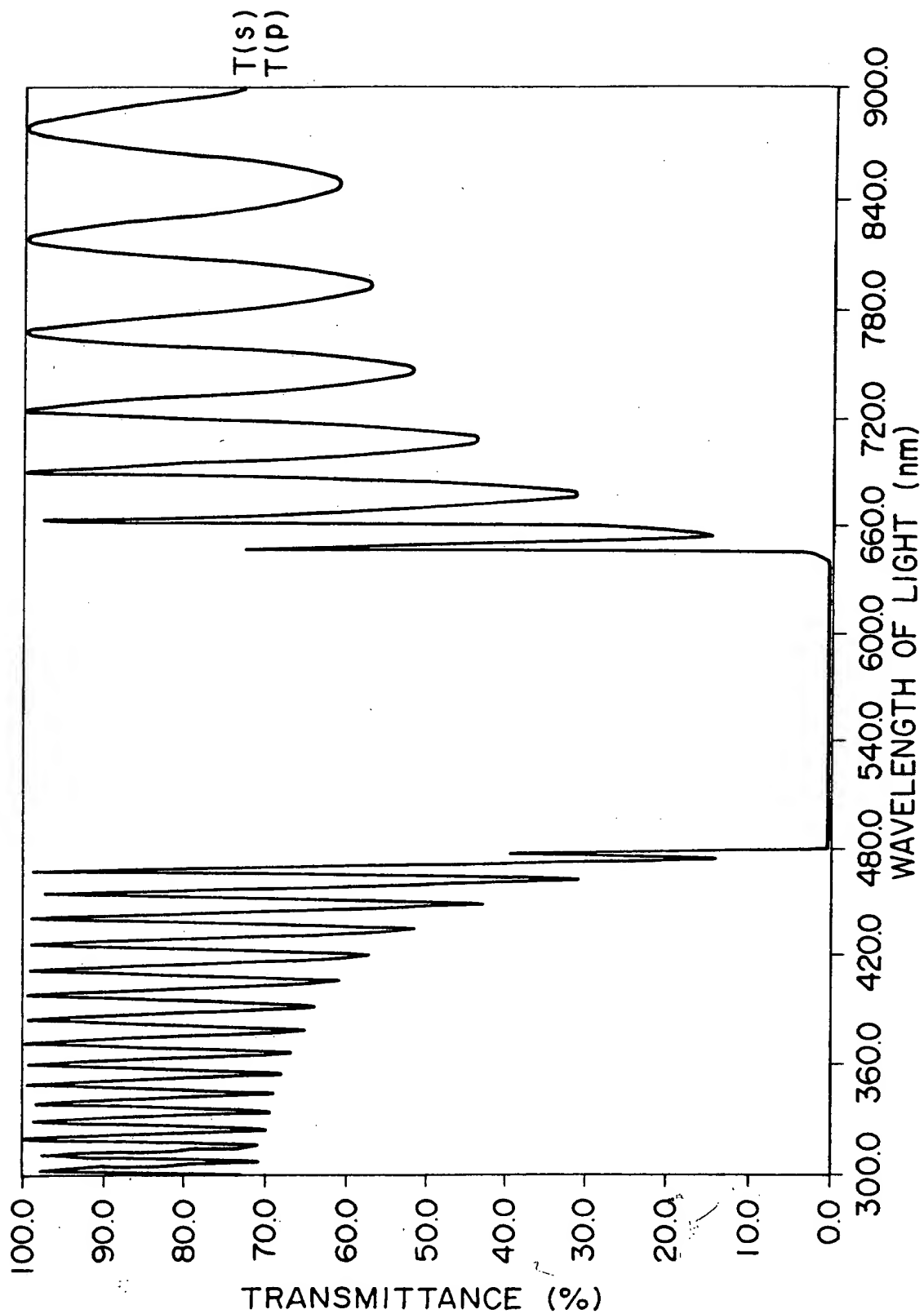


FIG. 5

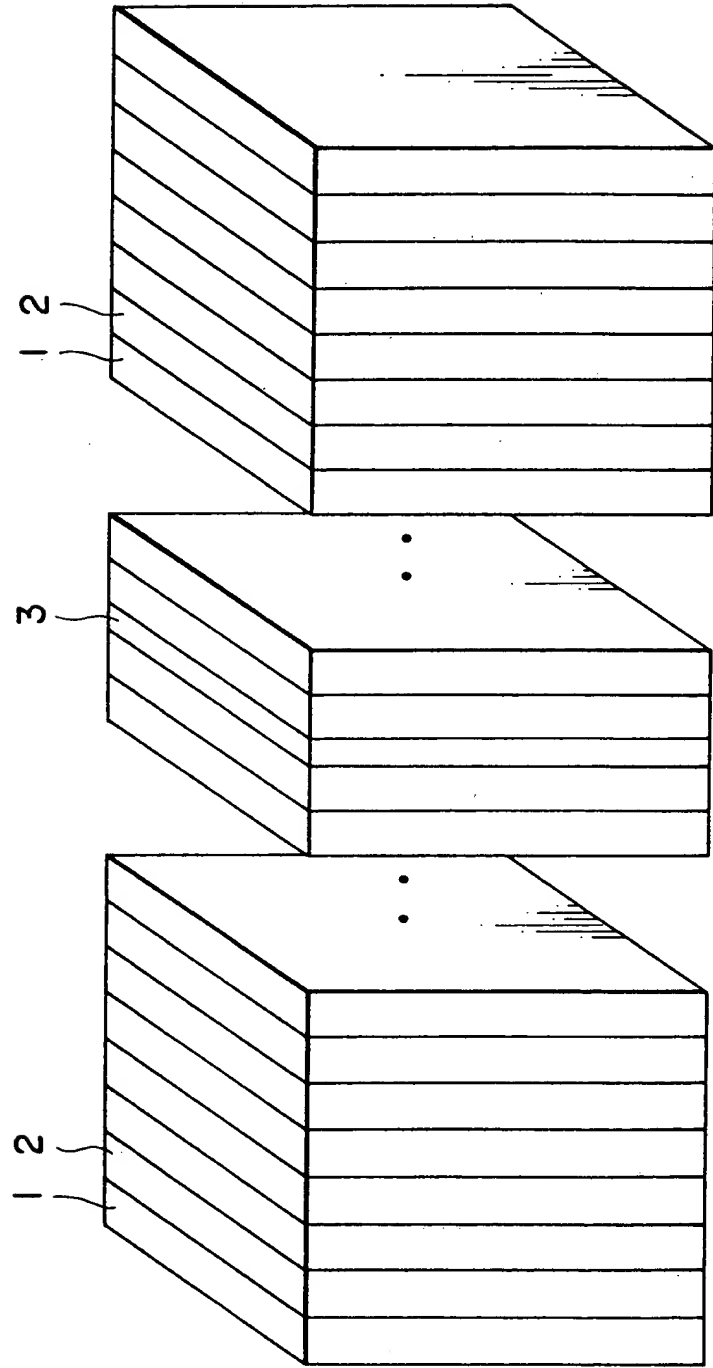


FIG. 6

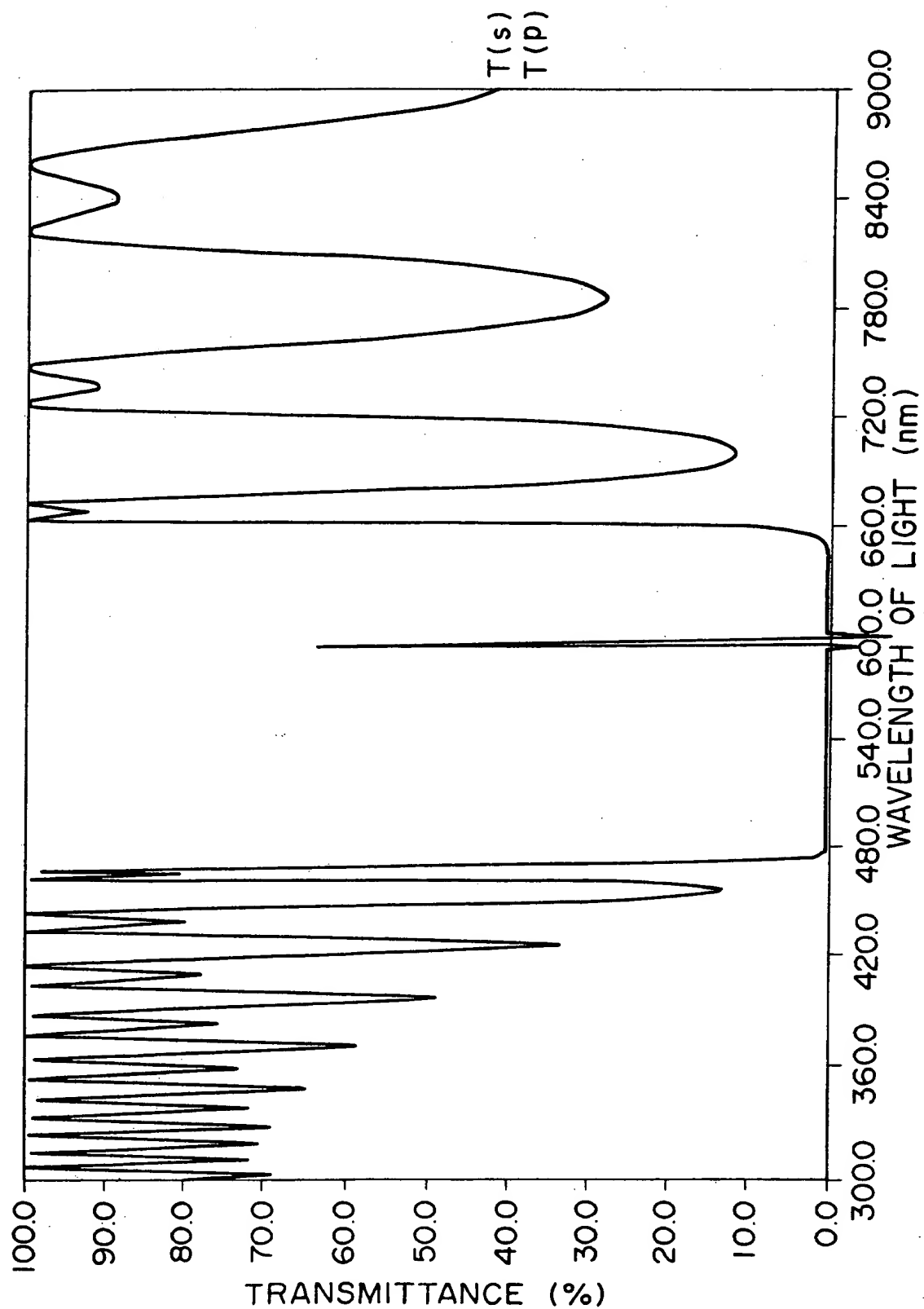


FIG. 7A

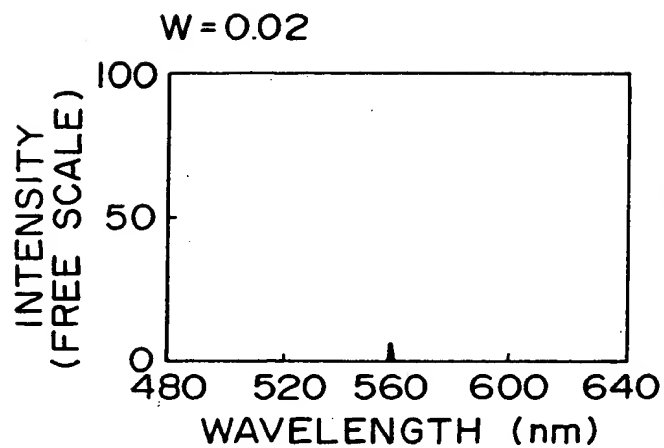


FIG. 7D

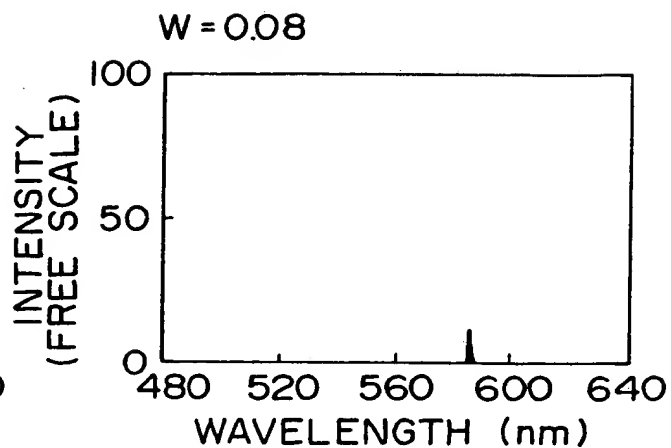


FIG. 7B

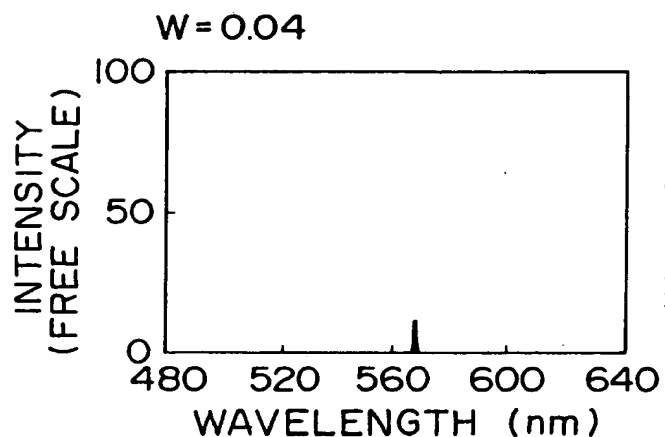


FIG. 7E

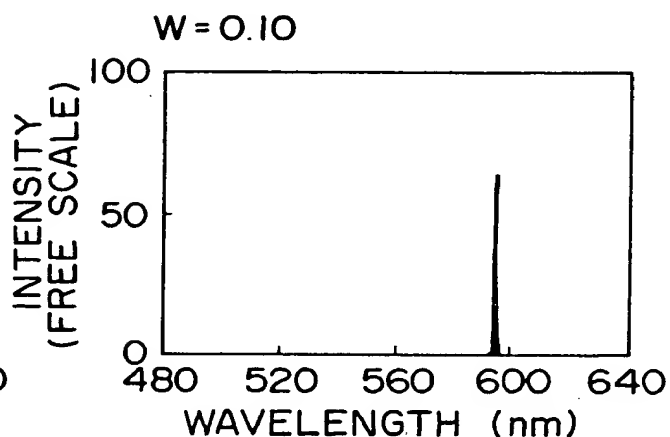


FIG. 7C

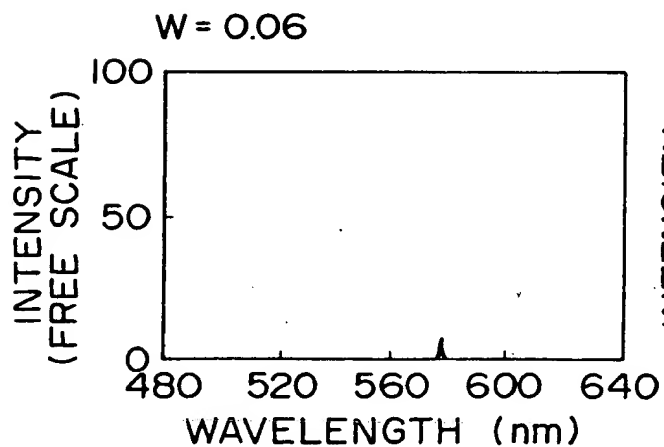


FIG. 7F

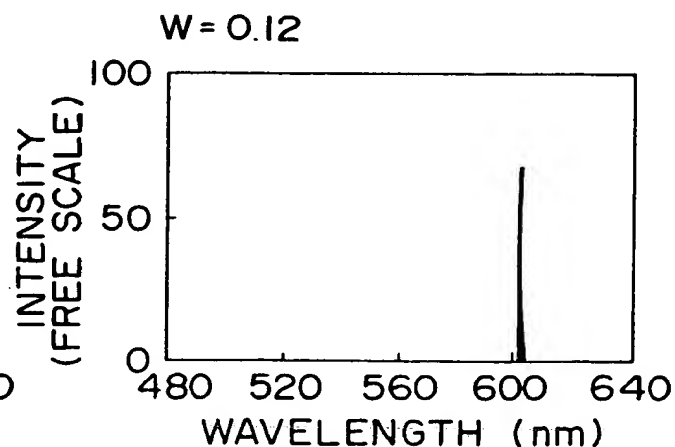


FIG. 8A

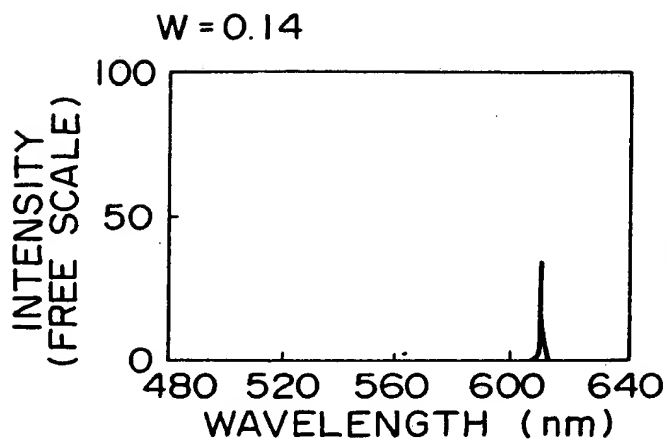


FIG. 8D

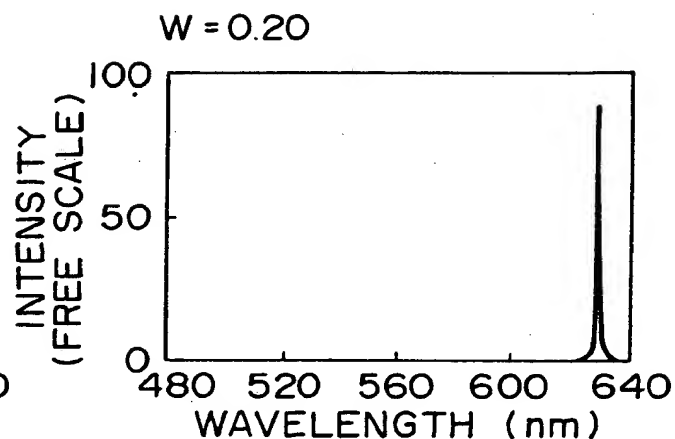


FIG. 8B

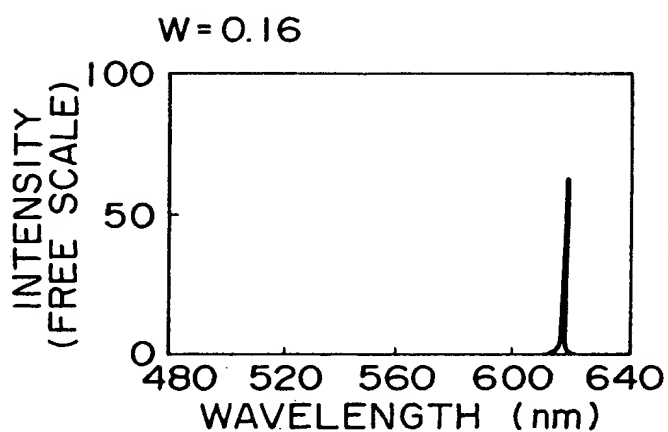


FIG. 8E

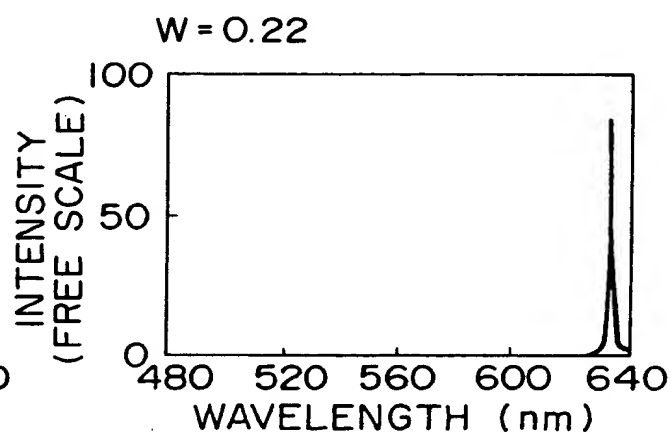


FIG. 8C

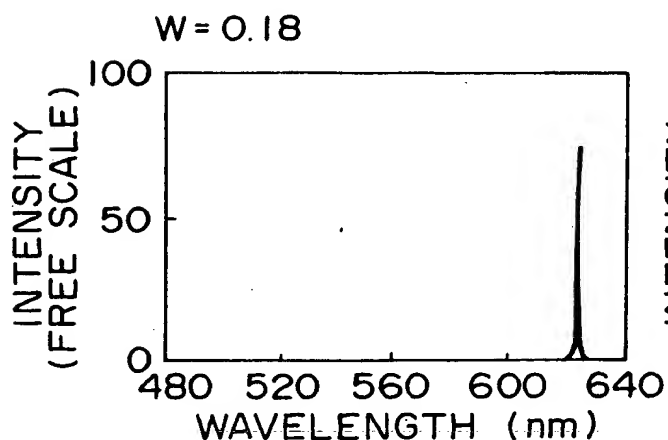


FIG. 8F

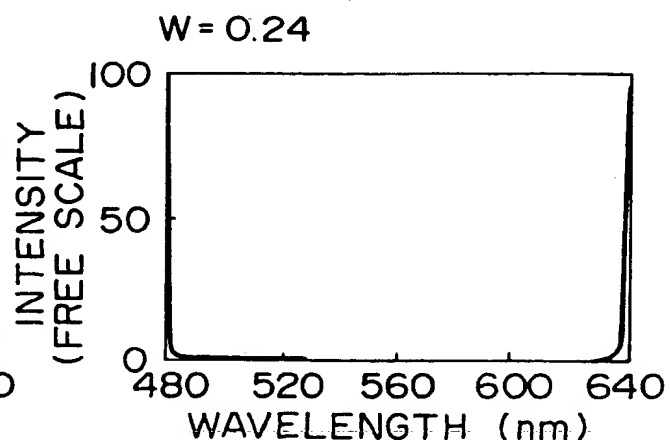


FIG. 9

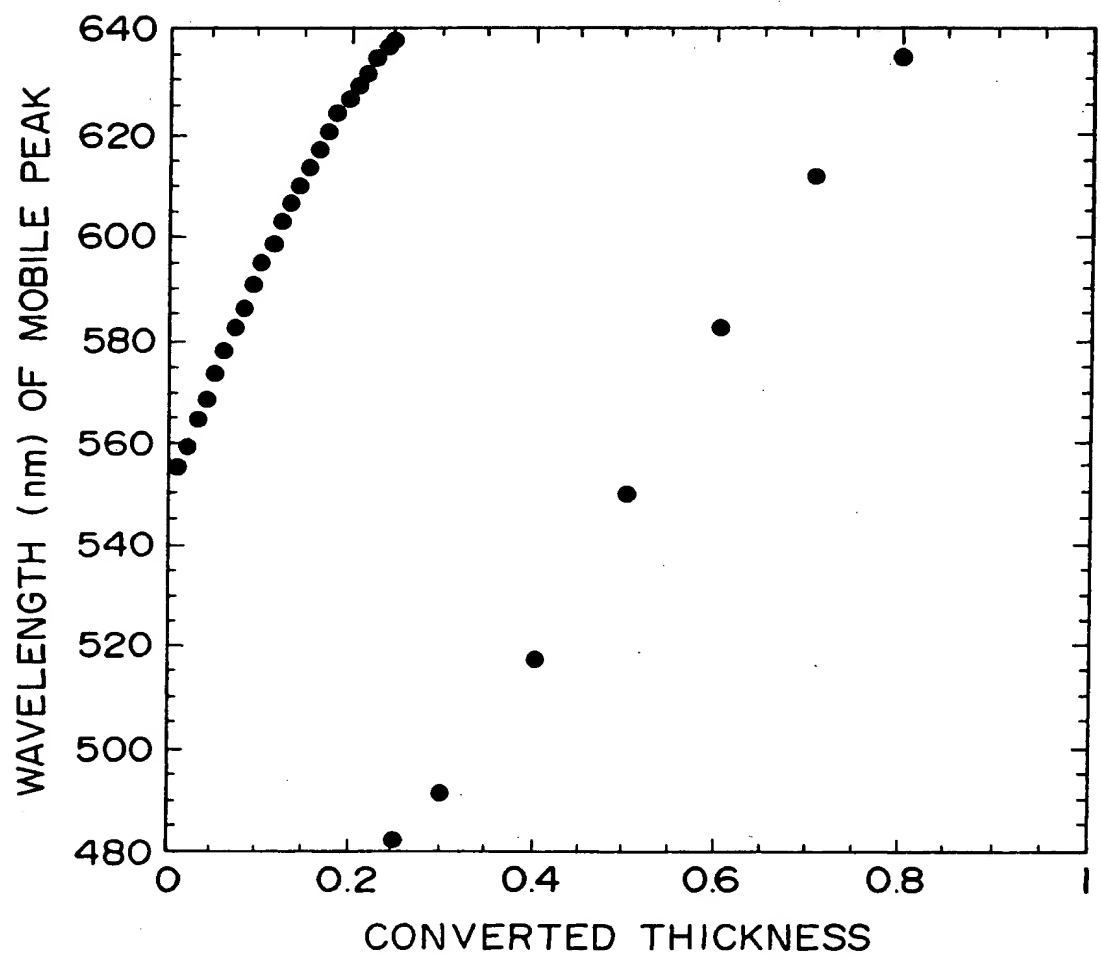


FIG. 10

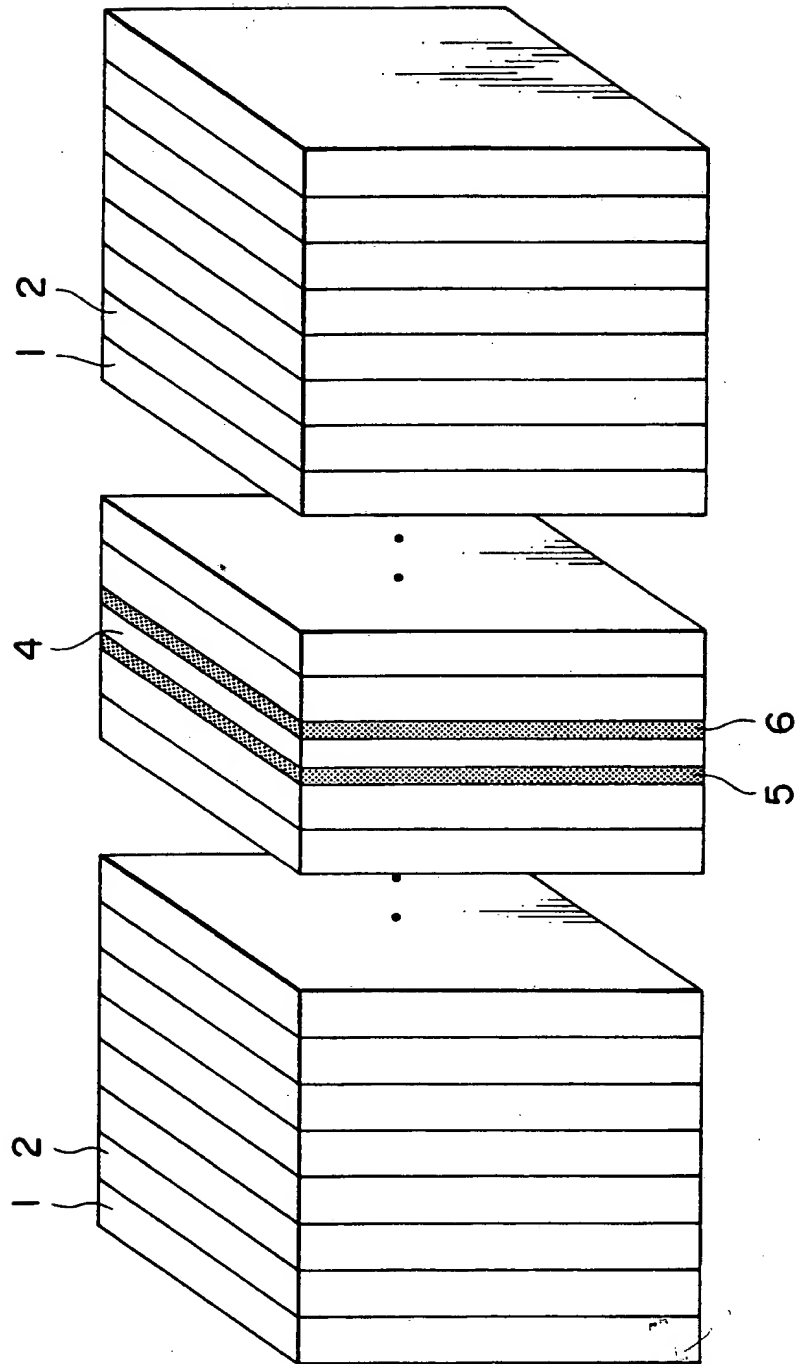


FIG. 11

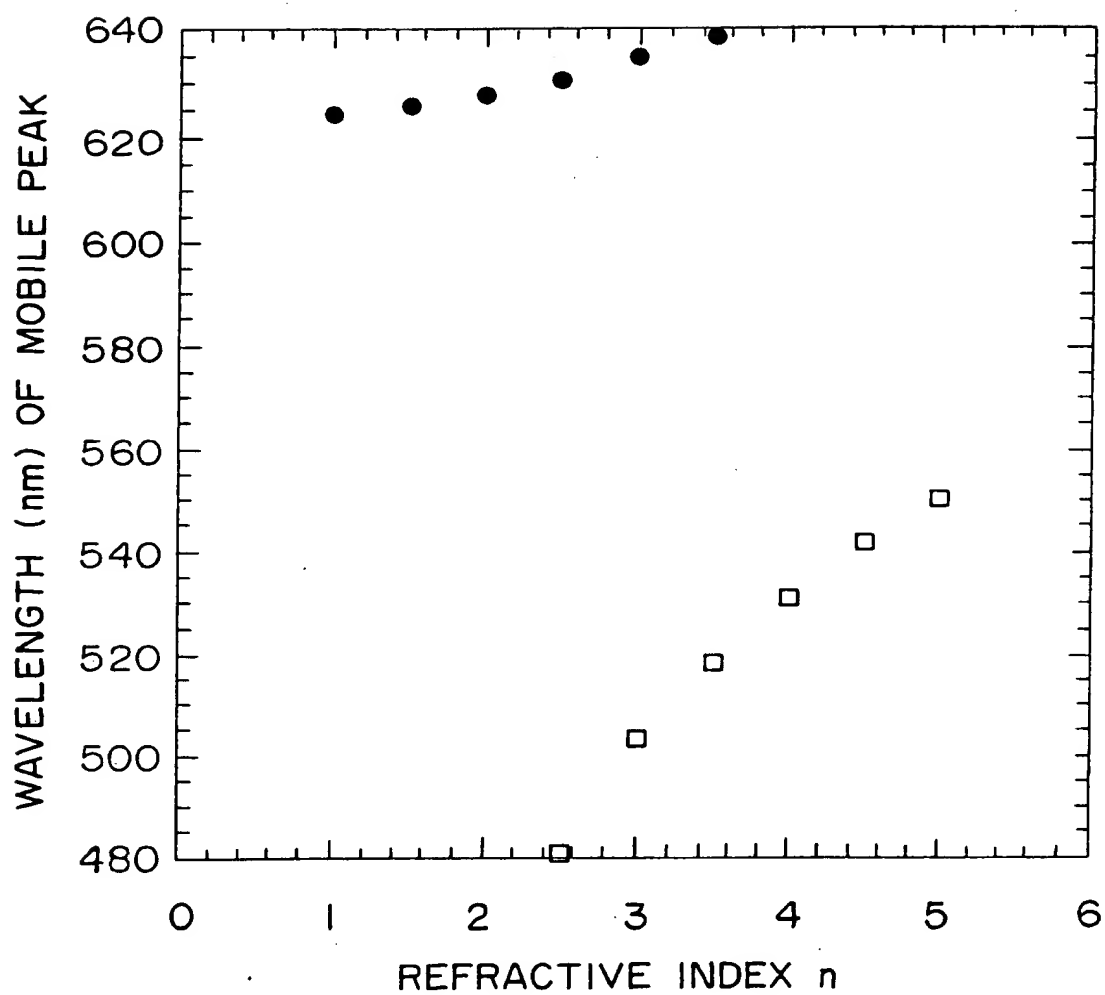


FIG. 12

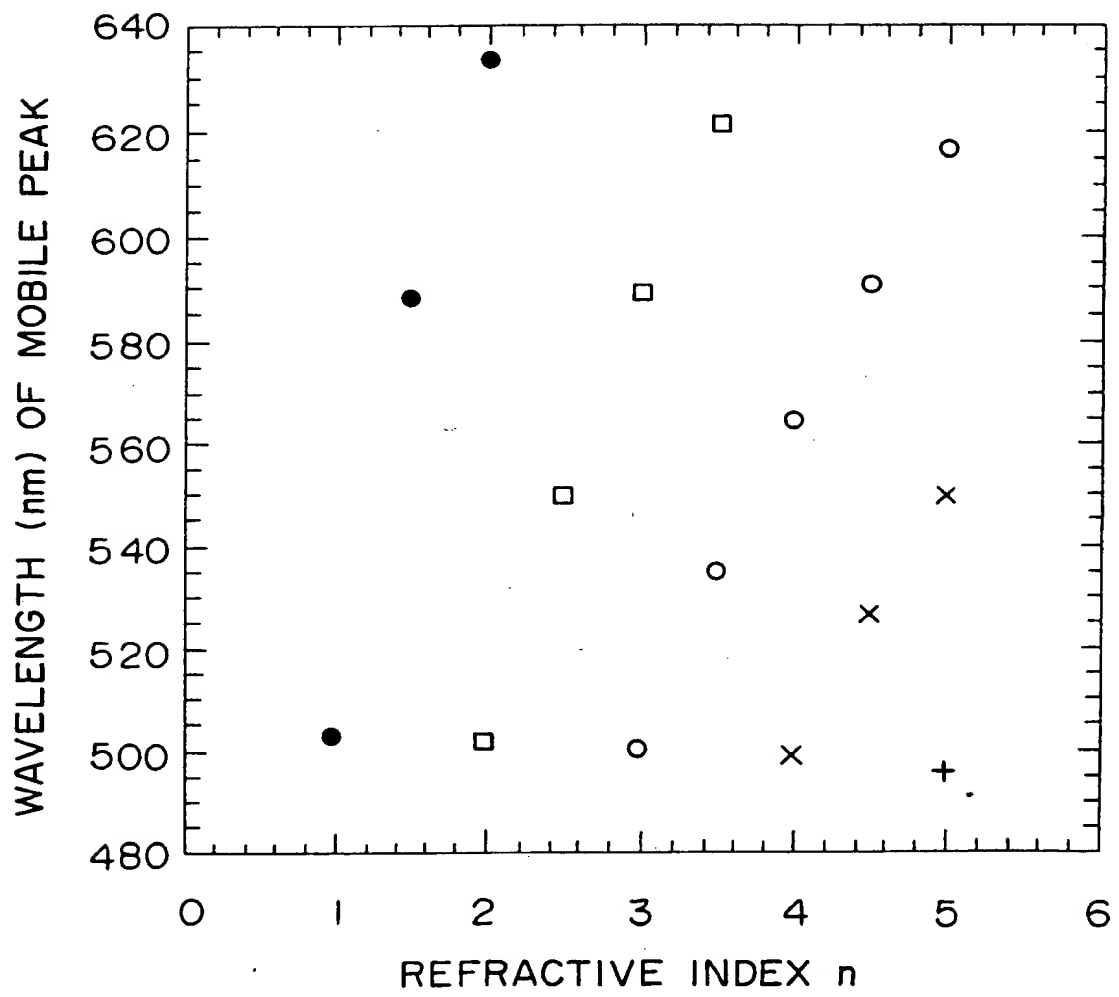


FIG. 13A

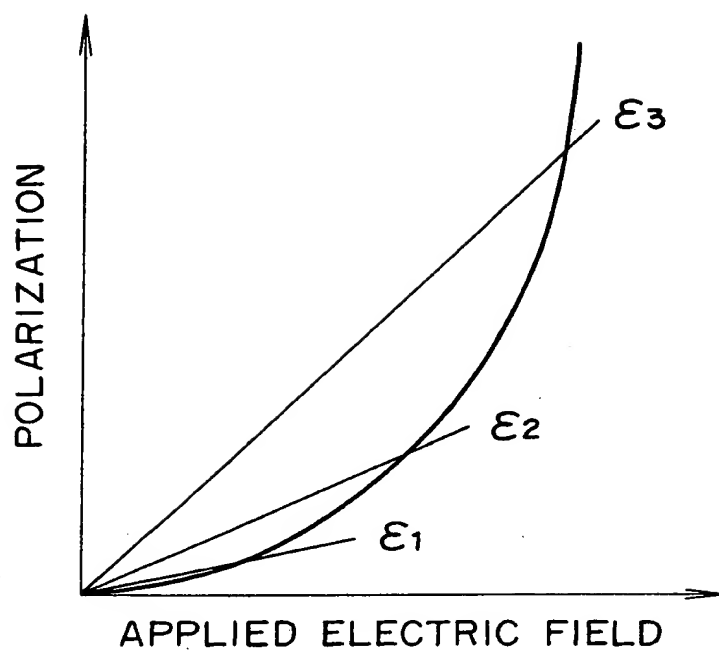


FIG. 13B

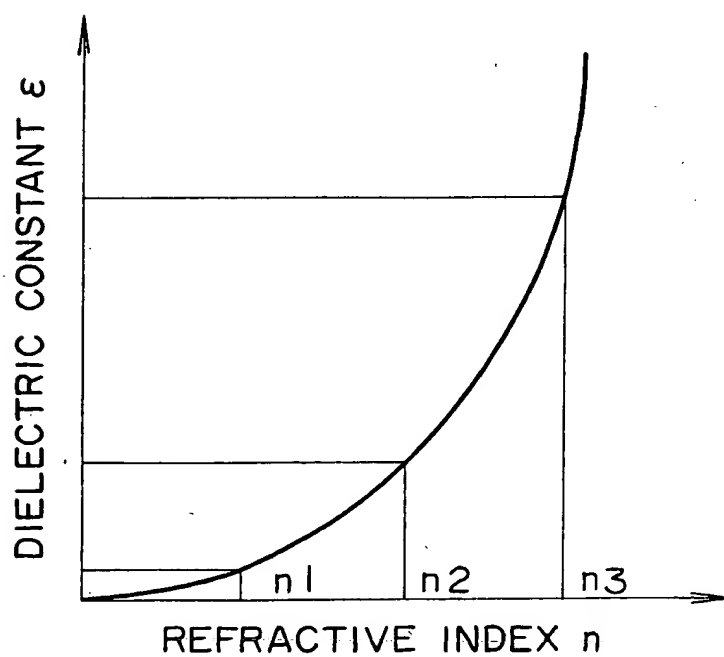


FIG. 14

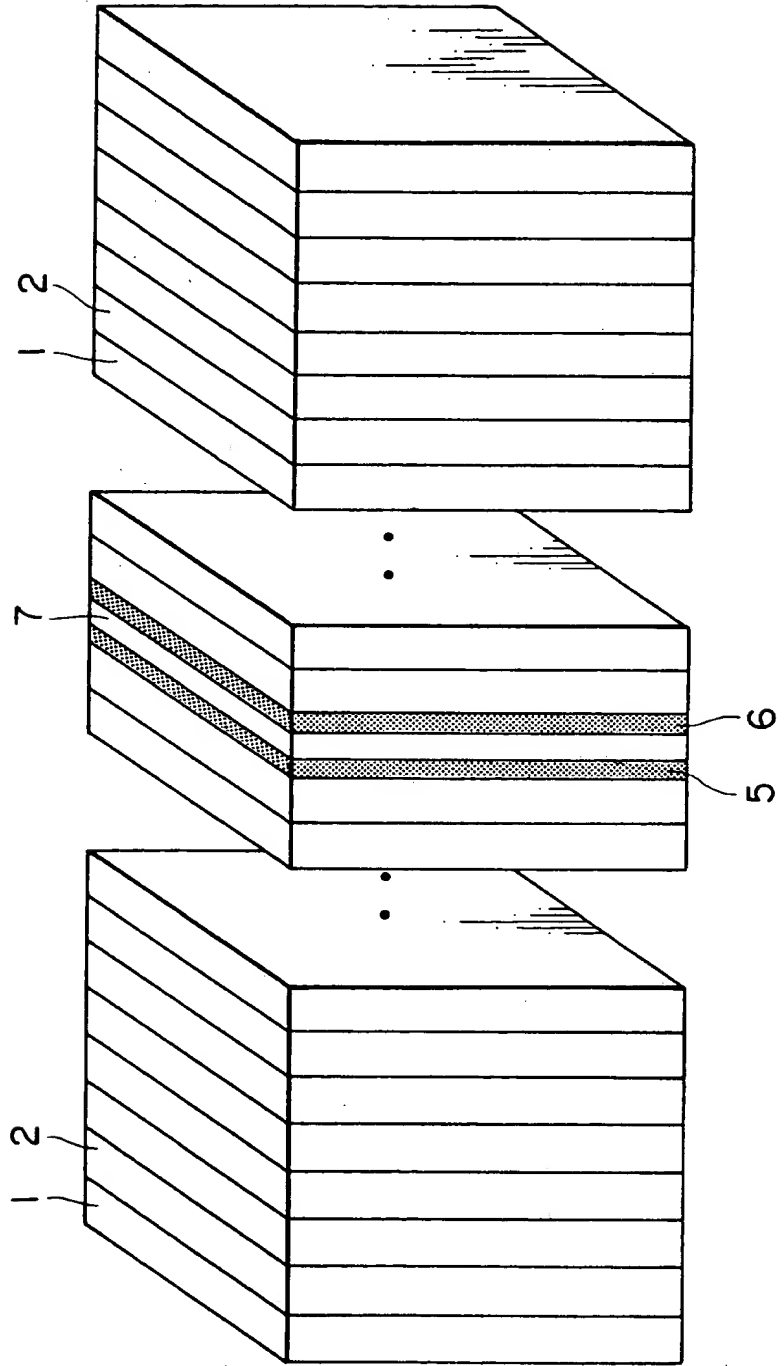


FIG. 15

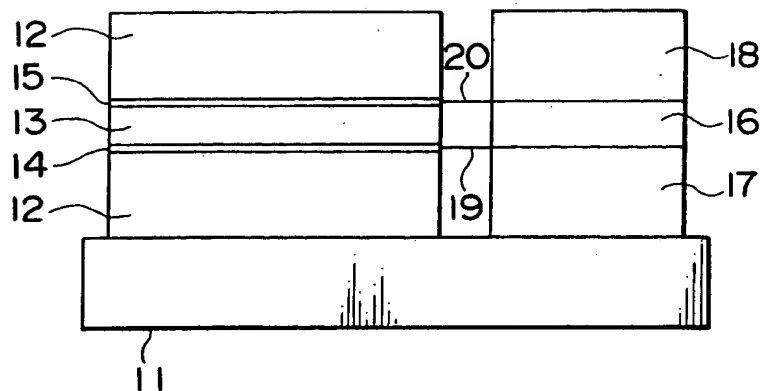


FIG. 16

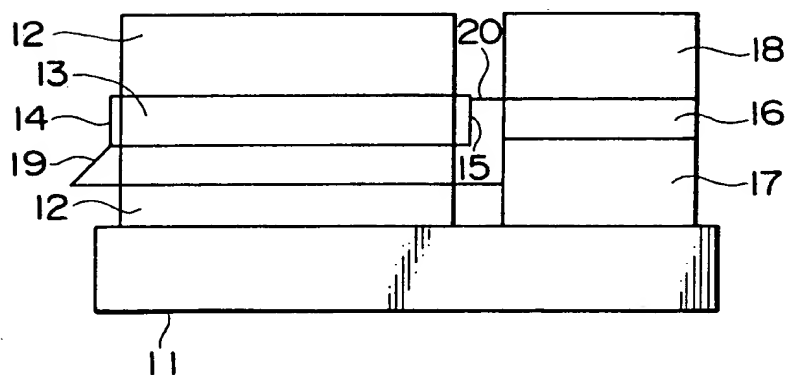


FIG. 17

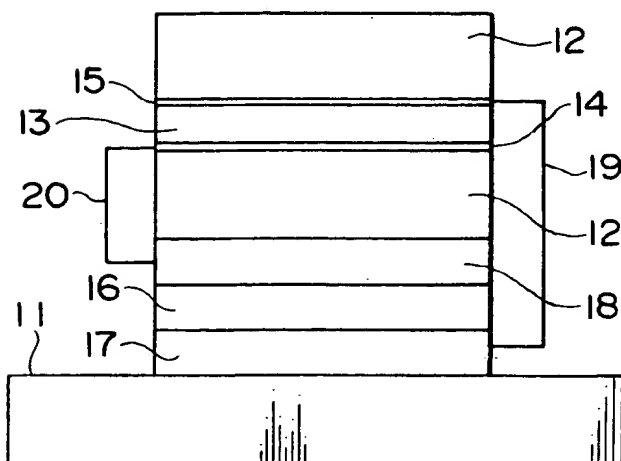


FIG. 18

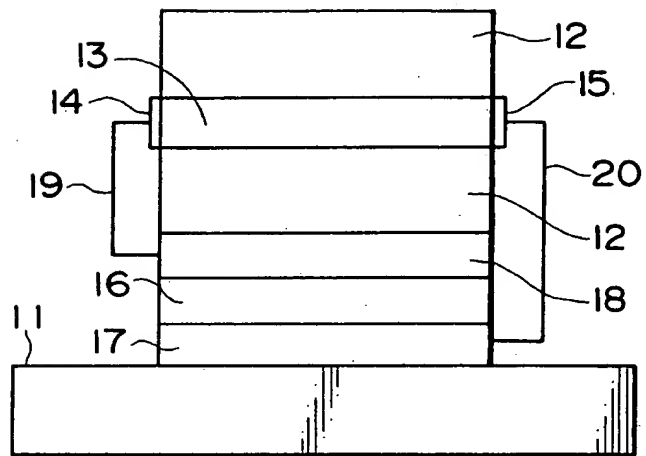


FIG. 19

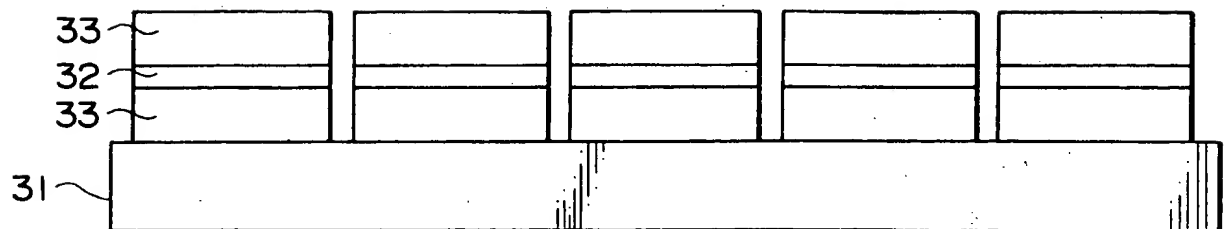


FIG. 20

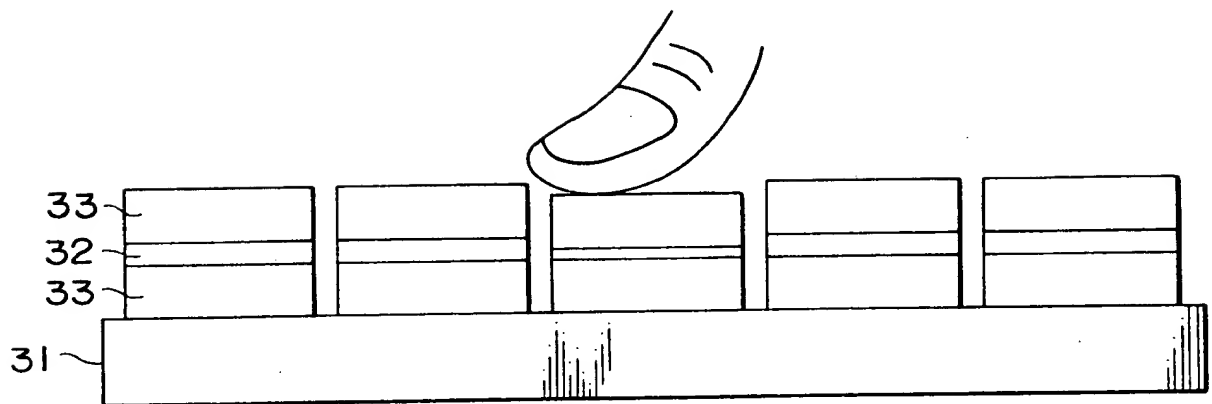


FIG. 21

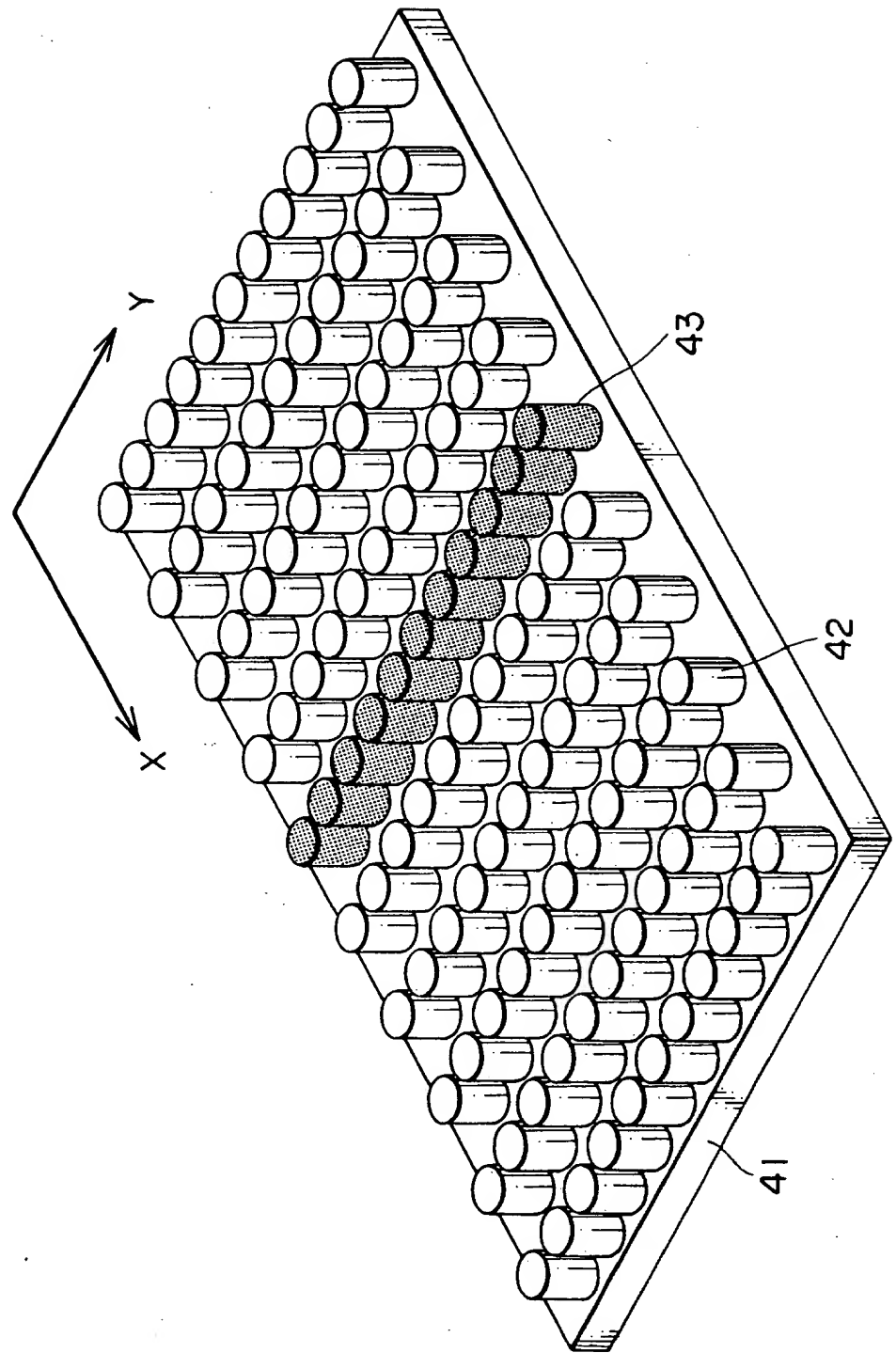


FIG. 22A

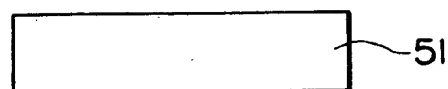


FIG. 22B

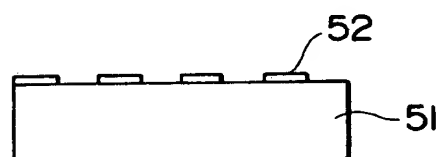


FIG. 22C

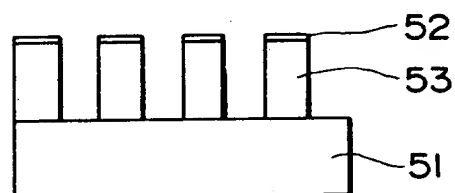


FIG. 22D

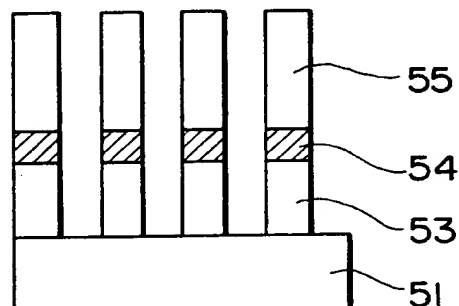


FIG. 23

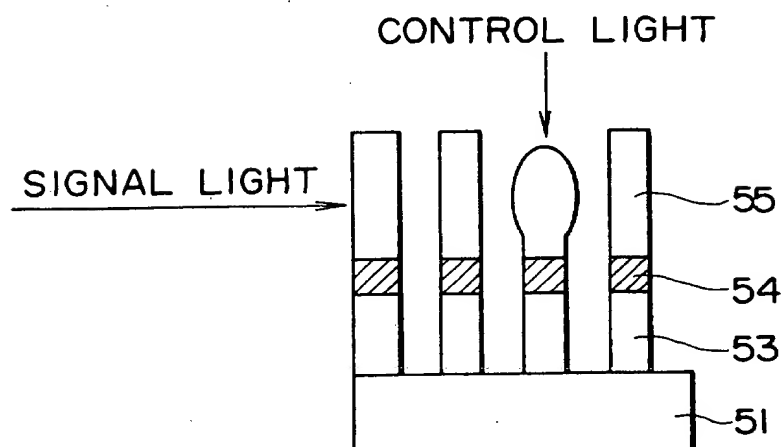


FIG. 24A



FIG. 24B

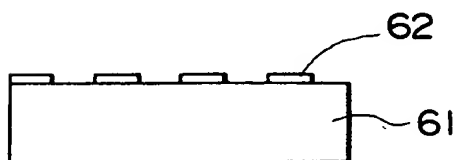


FIG. 24C

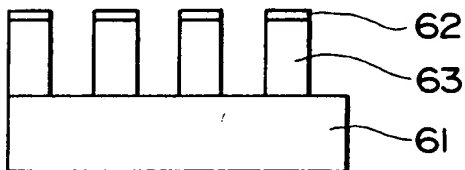


FIG. 24D

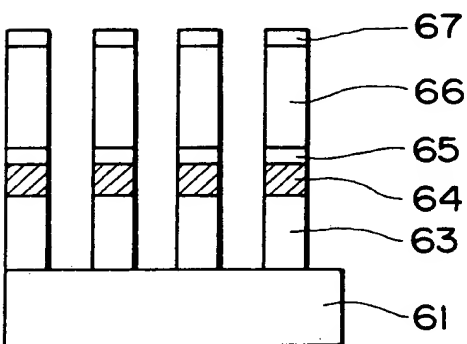


FIG. 25

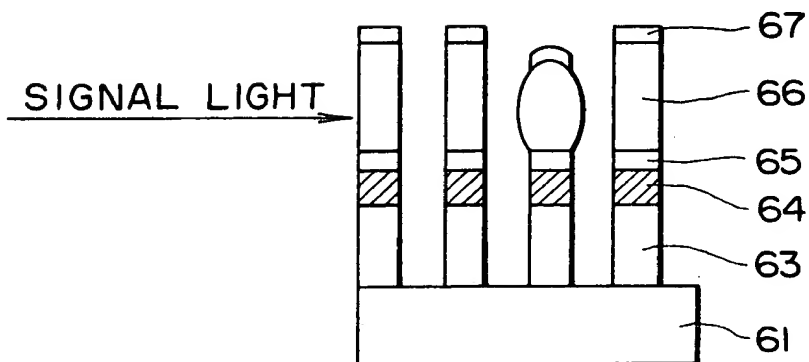


FIG. 26

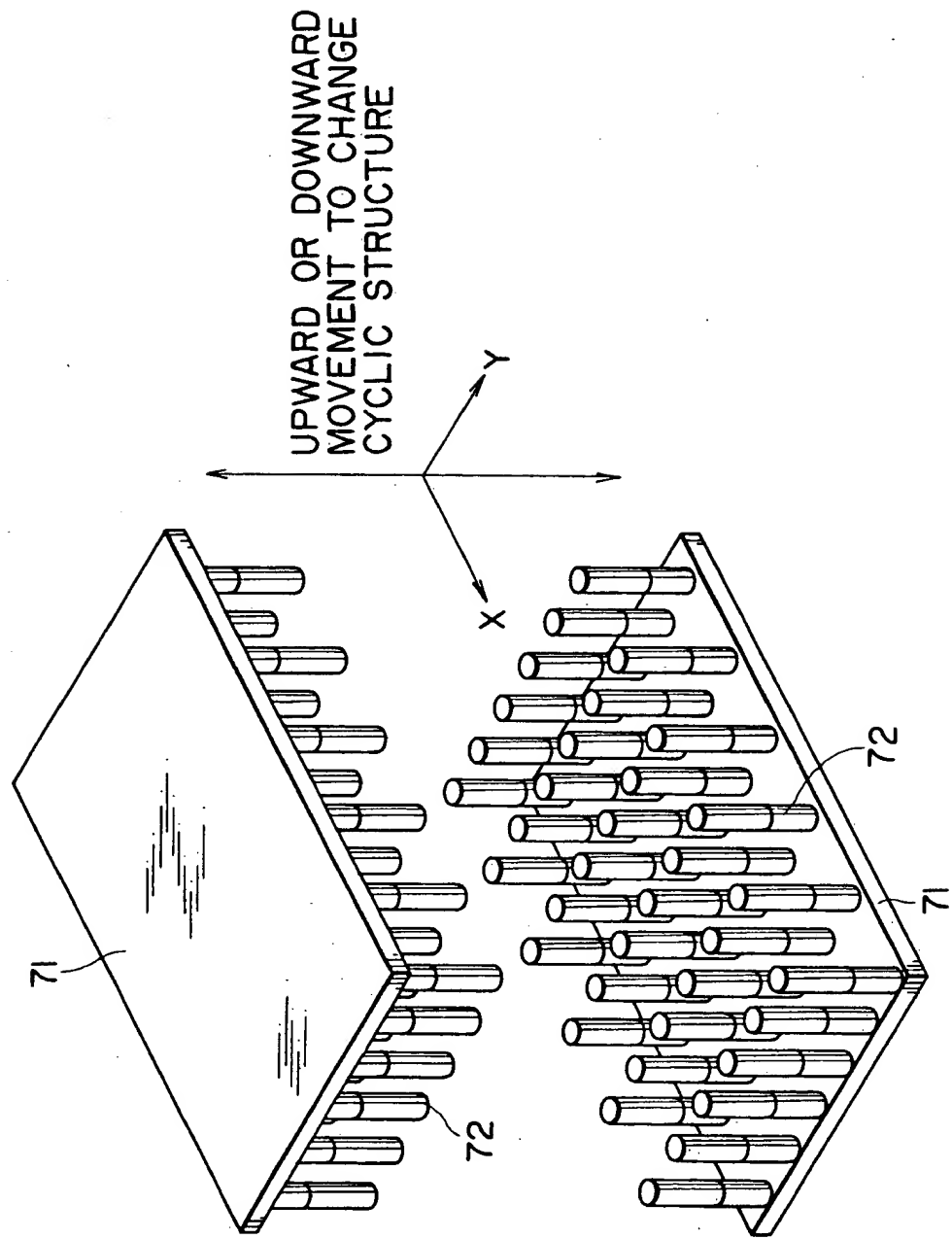


FIG. 27

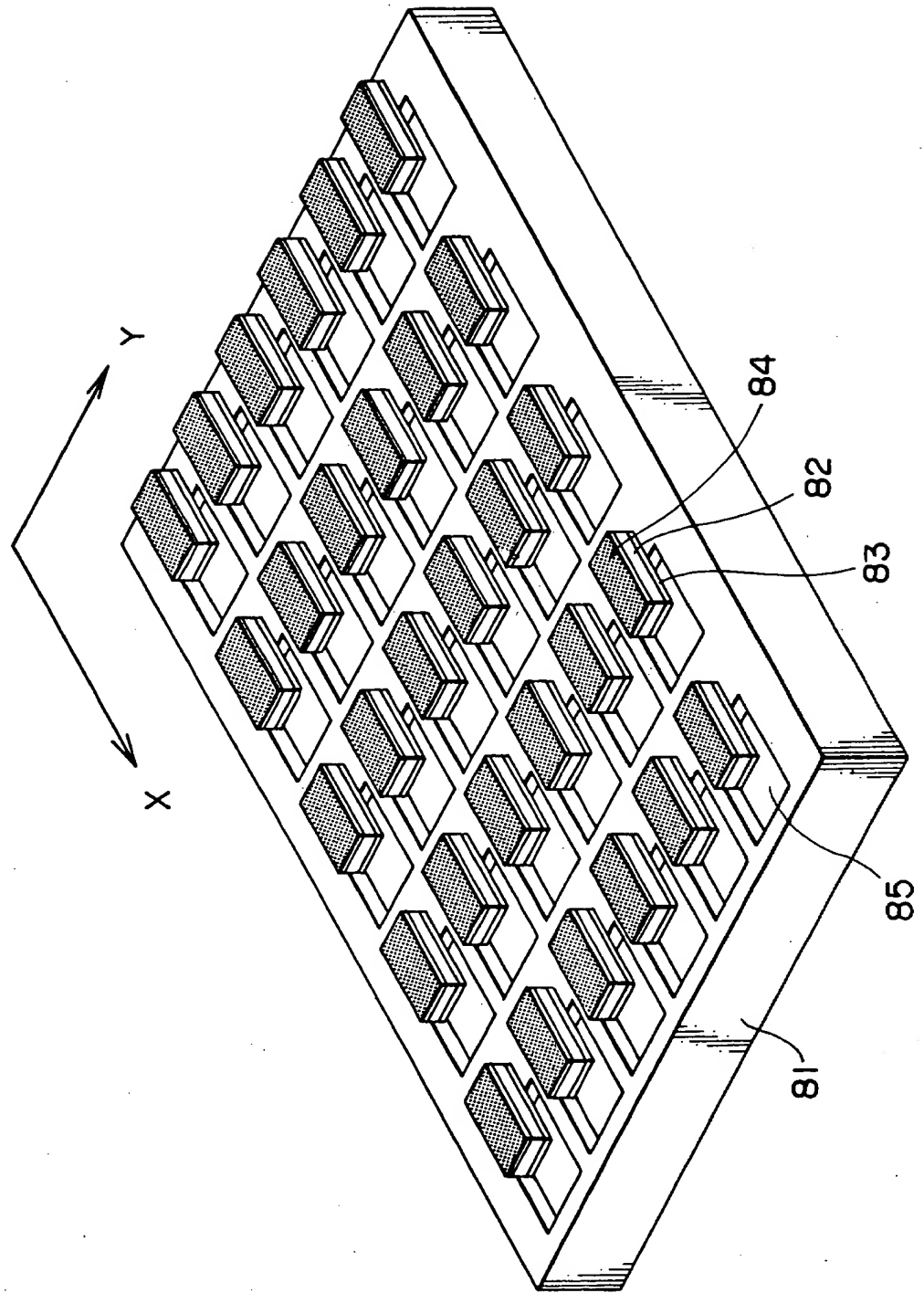


FIG. 28

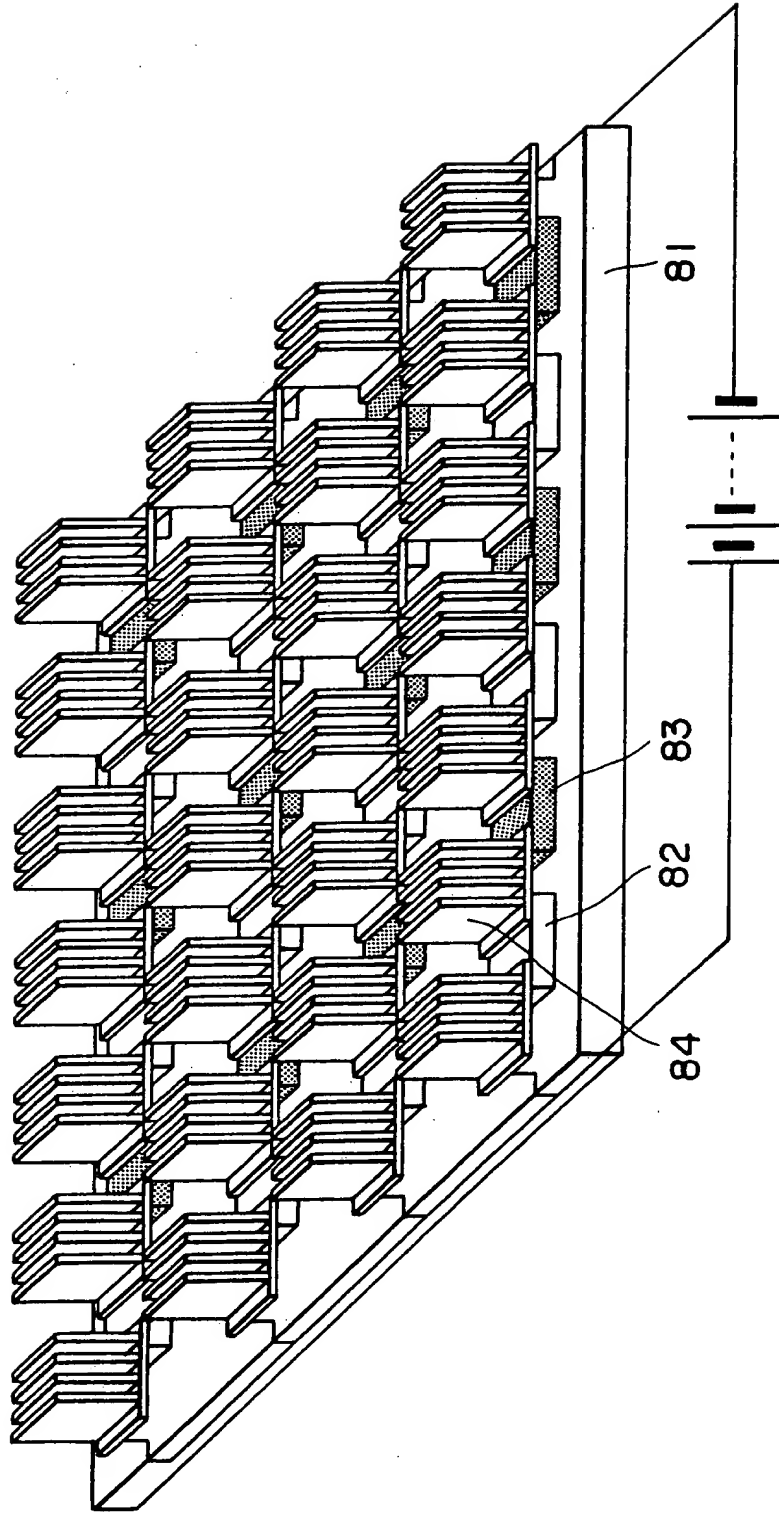


FIG. 29

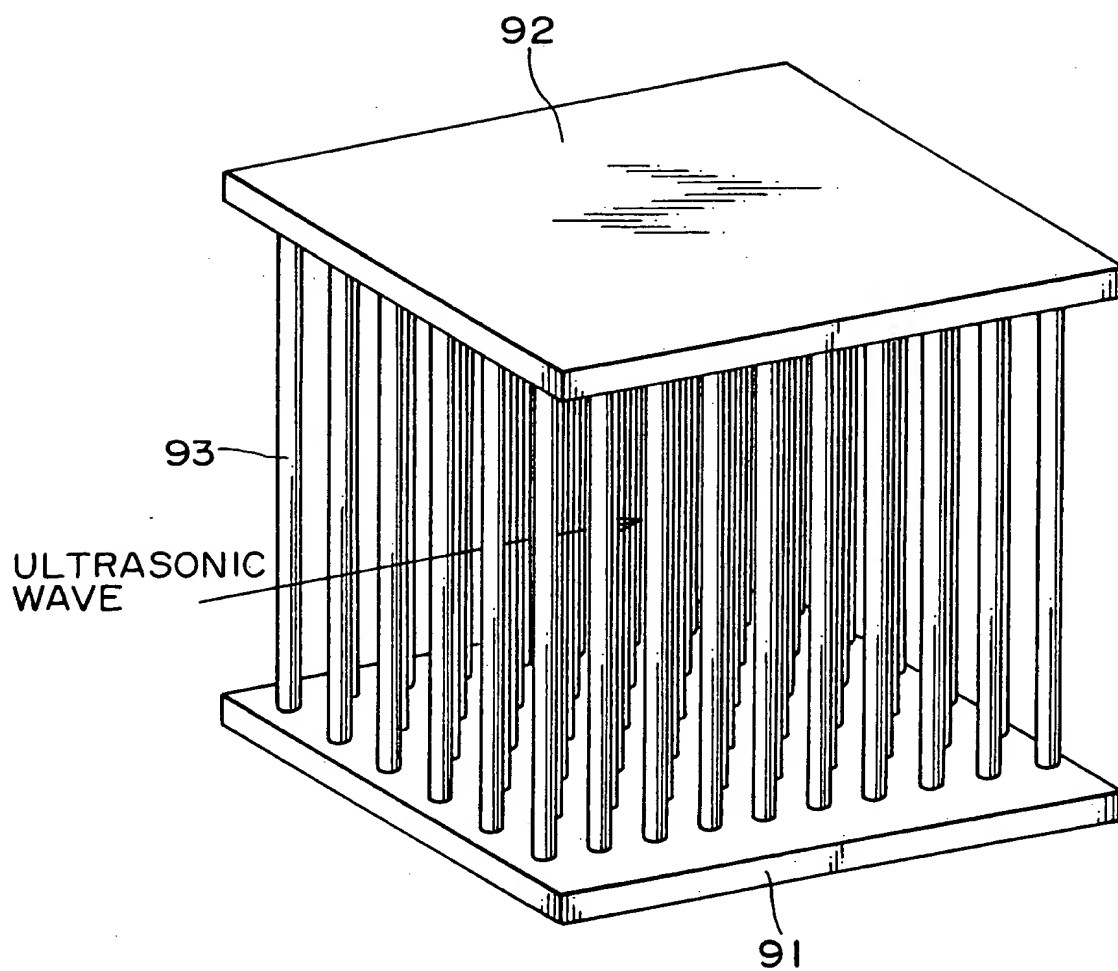


FIG.30

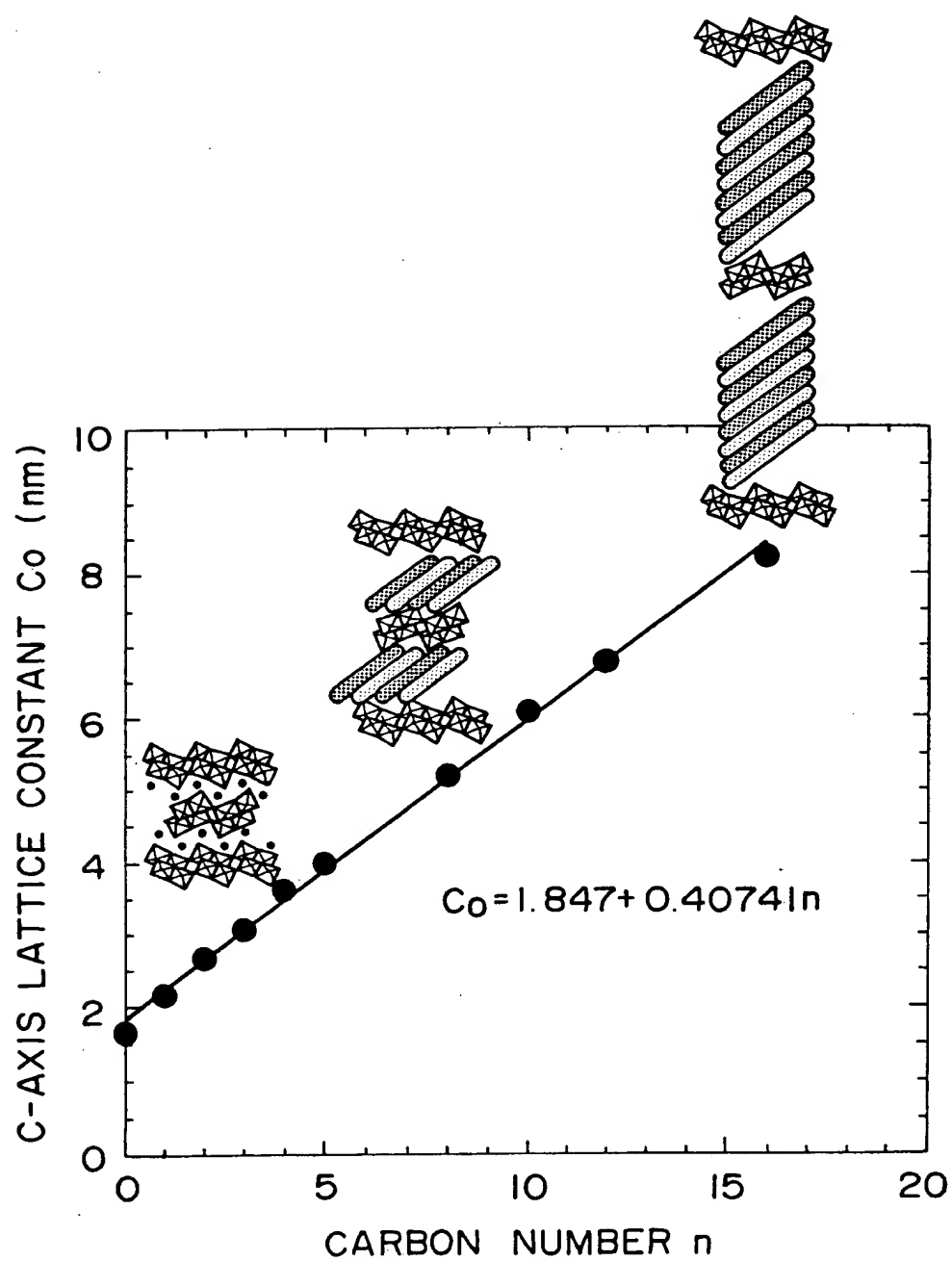


FIG. 31

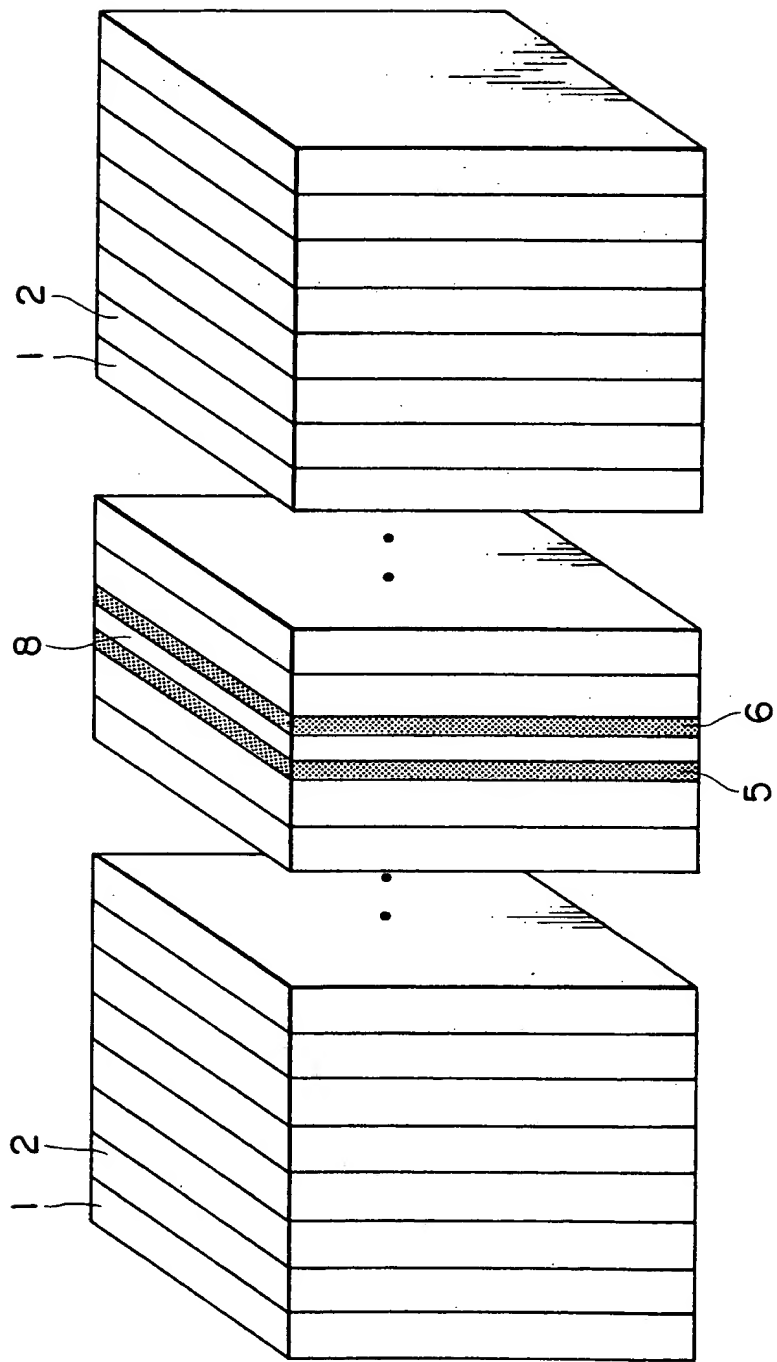


FIG. 32

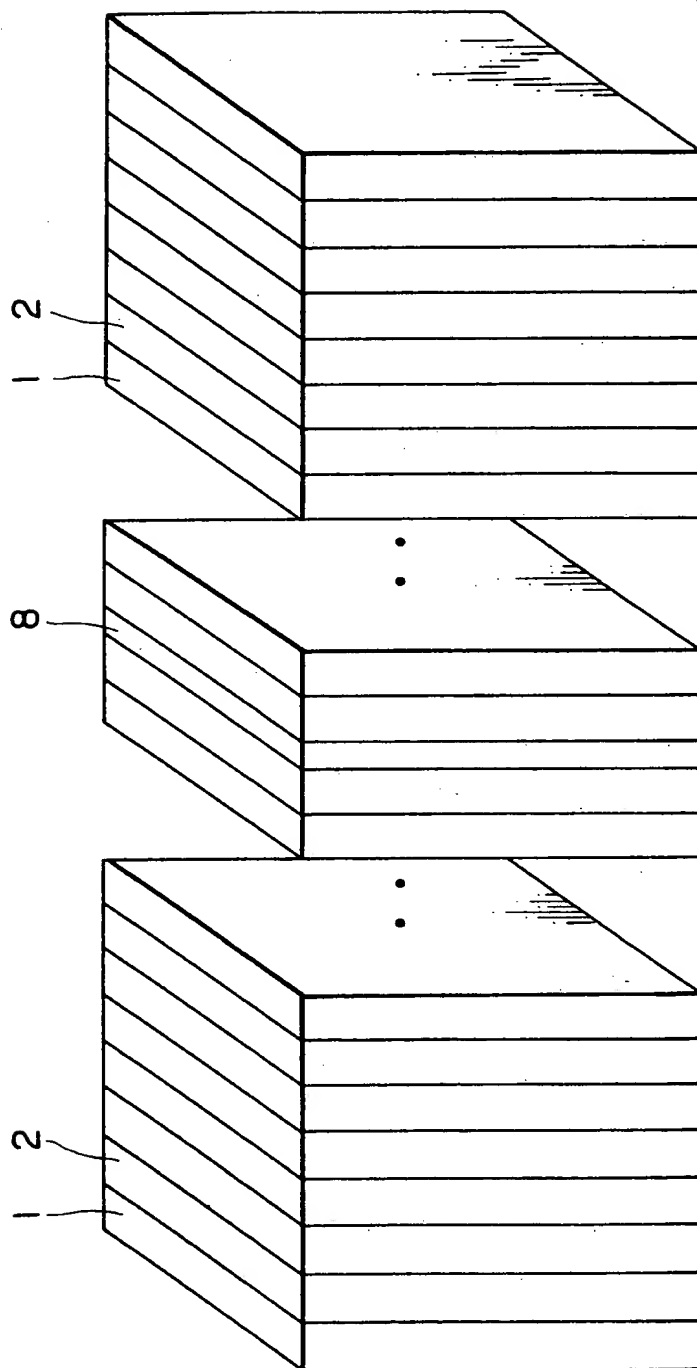


FIG. 33

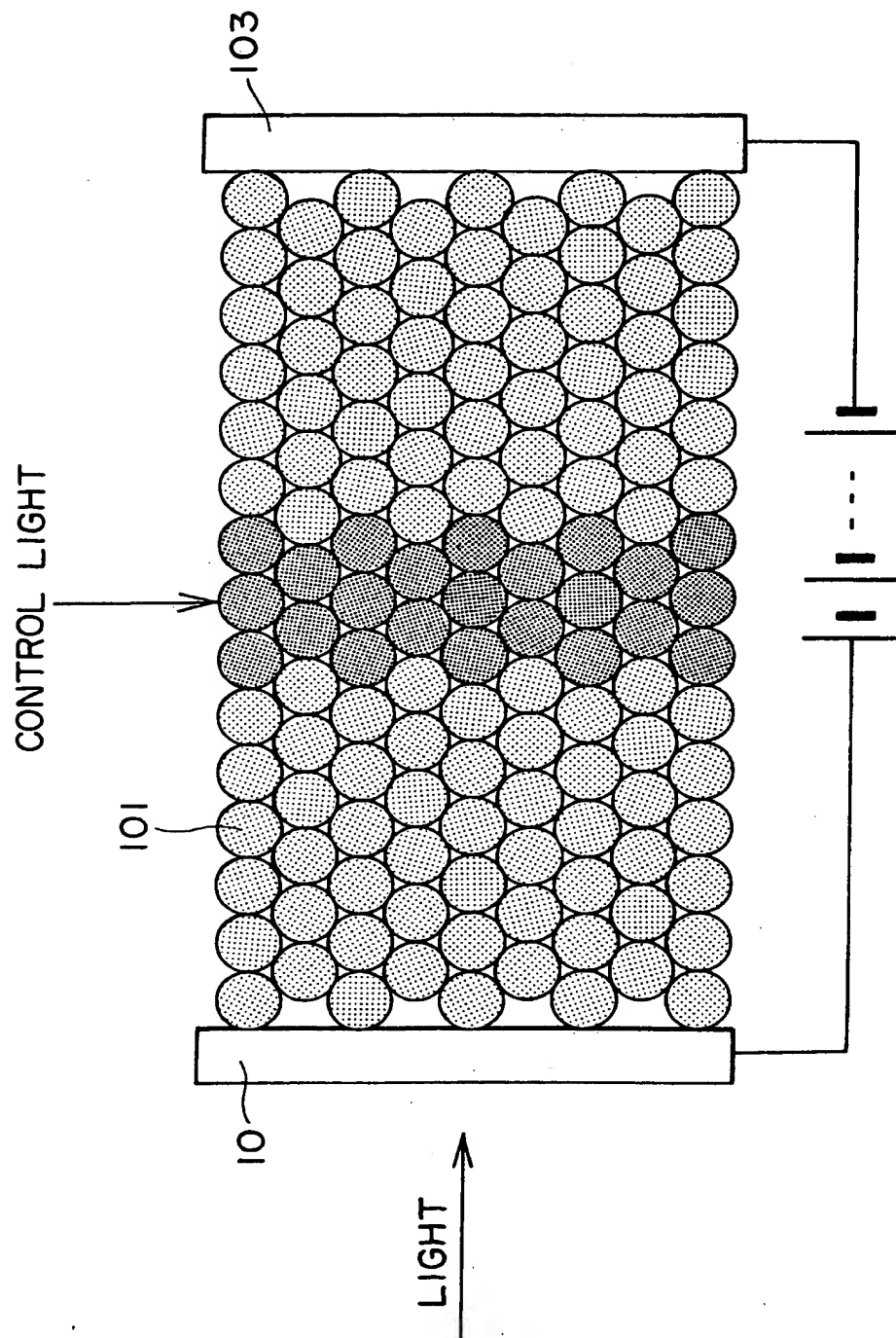


FIG. 34A

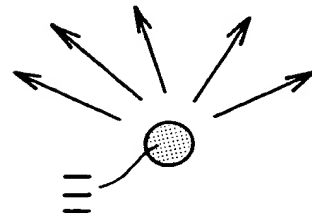
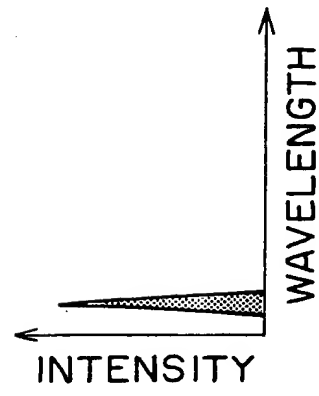


FIG. 34B

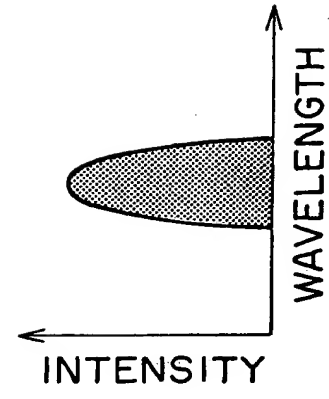


FIG. 34C

FIG. 35A

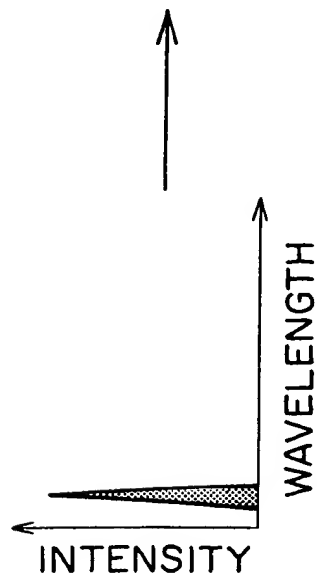


FIG. 35B

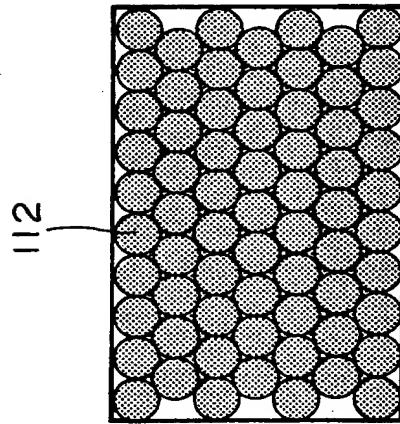


FIG. 35C

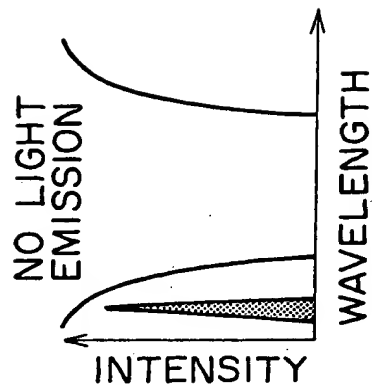


FIG. 36A

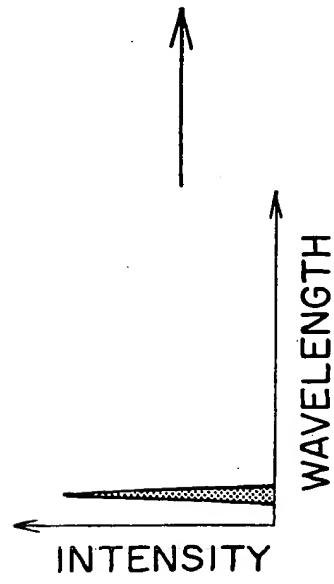


FIG. 36B

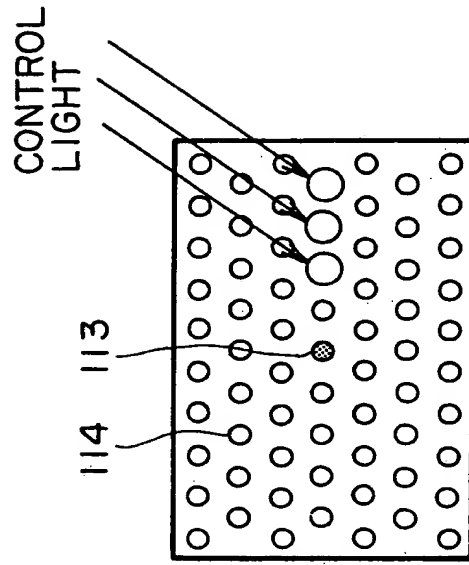


FIG. 36C

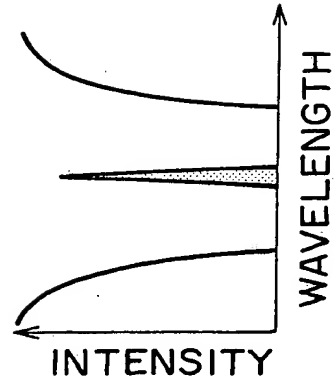


FIG. 37

CONTROL LIGHT
(FIELD CONTROL
BY POLARIZATION)

